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Comments on PADEP 2015 Draft *Nutrient Impact Assessment Protocol for Wadeable Streams*

Reservation of Rights

PADEP has not created a public docket on this matter nor has the Department made available for public review all of the data and backup analyses used to create the Protocol. This has prevented the full assessment of PADEP's proposed action and has prevented the submission of complete comments by the required deadline (November 17, 2015). The Coalition reserves its rights to submit additional comments once the agency makes available the records that have been requested. These records include the individual daily diel dissolved oxygen flux data along with the observed maximum and minimum dissolved oxygen concentration data for each flux as well as the statistical analyses used to select the nitrogen and phosphorus trigger values.

Introduction

PADEP's 2015 *Nutrient Impact Assessment Protocol for Wadeable Streams* (August 2015; hereafter, "Protocol") discusses PADEP's Nutrient Impact Assessment Protocol used to determine if nutrients are the cause of aquatic life use ("ALU") impairment in wadeable streams in Pennsylvania. Additional information regarding the derivation of the Protocol is documented in the *Development of a Nutrient Impact Assessment Protocol for Identifying Nutrients as a Cause of Aquatic Life Use Impairment in Pennsylvania Wadeable Streams* (PADEP, 2015; "Background Report").[1] If a stream is determined to be ALU-impaired, based on an evaluation of benthic macroinvertebrate data collected and processed in accordance with PADEP sampling protocol, the following procedures are used to confirm or reject nutrients as a cause of the ALU-impairment.

The Protocol is a seasonal, two-tiered procedure. Tier 1 of the assessment evaluates instream total nitrogen ("TN") and total phosphorus ("TP") concentrations and Hilsenhoff Biotic Index ("HBI") scores against the following benchmark values:

- Hilsenhoff Index Score ≥ 4.60, or
- Total Phosphorus ≥ 0.06 mg/l, or
- Total Nitrogen ≥ 2.6 mg/l

If any one of these three benchmark values is equaled or exceeded, the Protocol proceeds to the Tier 2 assessment.

The second tier of assessment compares stream conditions with the following daily <u>maximum</u> diel dissolved oxygen ("DO") range and maximum 7-day average diel DO range thresholds, separated by warm (*i.e.*, July 15-Sept. 15) and cool season (*i.e.*, remainder of year):

[1] PADEP. August 2015. *Development of a Nutrient Impact Assessment Protocol for Identifying Nutrients as a Cause of Aquatic Life Use Impairment in Pennsylvania Wadeable Streams*.

- Cool Season Daily Maximum Diel DO Range ≥ 4.8 mg/l, or
- Cool Season Maximum 7-Day Average Diel DO Range ≥ 4.2 mg/l, or
- Warm Season Daily Maximum Diel DO Range ≥ 6.1 mg/l, or
- Warm Season Maximum 7-Day Average Diel DO Range ≥ 5.4 mg/l

If any one of the applicable seasonal thresholds is equaled or exceeded, nutrients are identified as a cause of the aquatic life use impairment.

This Protocol was developed using "a stressor-response approach, based on *known* relationships between nutrient concentrations and biological responses, to develop a two-tiered protocol for assessing nutrient impacts to wadeable streams." (Protocol at 7; Background Document at 23) (Emphasis supplied).

Regulatory Background

Under the Clean Water Act ("CWA"), EPA and the States are tasked with the development of water quality criteria to protect the designated uses of waters of the United States. These uses typically include recreation (swimmable) and aquatic life support (fishable). A numeric criterion represents the threshold concentration of a substance necessary to protect those uses. Use impairment is not caused directly by ambient nutrient concentrations because nutrients (TN, TP) are not toxics. Rather, use impairment may result from the development of nuisance levels of algae and other alterations in aquatic vegetation in response to nutrient enrichment. Thus, numeric nutrient criteria must establish a biologically significant relationship with excessive plant growth using sound scientific procedures.

a. Both Federal and Commonwealth law require the Protocol to be based on a causal link between nutrients and the alleged impairment

The purpose of the Protocol is to create a narrative criteria implementation methodology by which pollutant reductions will be mandated under Section 303 of the Clean Water Act ("CWA" or "the Act"). It is axiomatic, that under the CWA, 33 U.S.C. §§ 1251 *et seq.*, regulatory actions respecting the need for water quality-based effluent limitations (such as those that will result from the Protocol) must be based on a showing that a particular pollutant is *causing* harm to a waterbody or that reduction of that pollutant is *necessary* to eliminate the impairment. *See also Nat'l Metal Finishers Ass'n v. EPA*, 719 F.2d. 624, 640 (3rd Cir. 1983) ("that neither the language of the Act nor the intent of Congress appears to contemplate liability without causation.") *rev'd on other grounds Chemical Mfrs. Ass'n v. Natural Res. Def. Council*, 470 U.S. 116 (1985); *Ark. Poul. Fed. v. Envtl. Prot. Agency*, 852 F. 2d 324, 328 (8th Cir. 1988) (stating the discharge must at least be "a cause" of the violation). For instance, all water quality-based limitations are based on a causation analysis - the pollutant reduction "necessary" to achieve applicable "water quality standards." CWA § 301(b)(1)(C); 40 C.F.R. § 130.7(b)(4) ("The list … shall identify the pollutants causing or expected to cause violations of the applicable water quality standards"); 40 C.F.R. § 122.44(d)(1) ("[E]ach NPDES permit shall include… (d) any requirements… necessary to (1) achieve water quality standards…., including narrative criteria for water quality.").[2] Additionally, EPA guidance on nutrient regulation for streams and rivers explicitly requires cause and response relationship *USEPA Nutrient Criteria Technical Guidance Manual – Rivers and Streams* (2000, EPA 822/B-00-002) discussing the need to develop causal and response variables Finally, EPA guidance explains that valid cause and effect based on ambient data must be used to make predictions for nutrients. EPA Stressor Response Guidance, at 6, 32.

Similarly, the applicable Pennsylvania water quality standard is the general narrative standard found at 25 Pa. Code § 93.6(a) ("Water may not contain substances attributable to point or nonpoint source discharges *in concentration or amounts sufficient to be inimical or harmful* to the water uses to be protected or to human, animal, plant or aquatic life.") (emphasis added). This narrative criteria does not define specific concentrations or limits, but it does require a specific "causal" link between the amount of a pollutant and harm to the waterbody. Moreover, the Department interprets the narrative criteria based on published guidance entitled *Assessment and Listing Methodology for Integrated Water Quality Monitoring and Assessment Reporting* that outlines what constitutes a nutrient impairment in Pennsylvania waters. This methodology, used to interpret the narrative standard with respect to nutrients, along with all other published DEP guidance, specifically requires nutrients to be <u>causing excessive plant growth</u> and/or <u>violations in the dissolved oxygen standard</u> to conclude a narrative criteria violation exists.[3]

As discussed in more detail below, the Department's Protocol does not include the requisite causal relationship between nutrients, DO variation and the alleged impairment of concern (*e.g.*, aquatic life). This omission must be corrected prior to the publication of any final document.

b. DEP failed to analyze important information in its possession

In issuing its Protocol, DEP must generally ensure that its action is not "arbitrary [or] capricious, an abuse of discretion or [] contrary to law." *See Firetree, LTD. v. Dep't of Corr.*, 3 A.3d 762, 764 n.5 (Pa. Commw. Ct. 2010); *Smedley v. DEP*, 2001 E.H.B. 131, 2001 Pa. Envirn. LEXIS 8, *43 (EHB Docket No. 97-253-K February 8, 2001) (Reviewing standard for DEP is "whether the findings upon which DEP based its actions are correct and whether DEP's action is reasonable and appropriate and otherwise in conformance with the law."). An agency action is arbitrary and capricious if "the agency has relied on factors which Congress has not intended it to consider, entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise." *Motor Vehicle Mfrs.*

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[2] *See Ohio Valley Environmental Coalition, Inc. v. FOLA Coal Company, LLC*, 2015 U.S. Dist. LEXIS 8904, *62-*70 (S.D. W. Va. Jan. 27, 2015) (in implementing a narrative standard, consideration of other possible (confounding) factors that could cause the same effect is required).

[3] DEP Listing Methodology, Appx. A at 6 (definition of "nutrient impairment"); *see also* Final Implementation Guidance for Section 95.9 Phosphorus Discharges to Free-Flowing Streams, Department of Environmental Protection, Bureau of Watershed Conservation, Document I.D. #391-2000-018 95.9, at 7; PADEP, Bureau of Watershed Conservation, Water Quality Monitoring and Assessment Section, Stream Enrichment Risk Analysis, Document I.D. #361-3200-007 (June 10, 1997), at 3.

Ass'n v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29, 43 (U.S. 1983).[4] In this case, as discussed individually below, in issuing the Protocol, DEP has failed to consider the following information necessary to create a scientifically defensible narrative implementation methodology or to select appropriate indicator criteria:

- How algal (periphyton) growth is controlled by nutrient levels and relates to the selected indices

- How diel DO variation is affected by physical parameters and is related to invertebrate population impairment

- How upstream conditions and habitat changes below a discharge influence plant growth and invertebrate metrics, regardless of algal growth present or DO variation

- Available detailed studies in DEP's possession showing that the predicted stressor-response evaluations are misleading/contrary to the more detailed site-specific findings (*e.g.*, studies on Indian, Goose, Paxton and Wissahickon Creek).

- A confounding factors evaluation regarding, at a minimum, the co-varying conditions know to directly affect the invertebrate indices

- The degree of algal growth occurring at the acceptable benchmarks

- The ability of nitrogen to control plant growth in fresh waters

- Whether combining warm and cold water fishery databases and streams with major urban influences created an inherent bias in the analyses presented

- How the indices were influences by non-growing season conditions

- Whether the analyses were consistent with EPA's Published Section 304(a) Guidance on Stressor-Response Evaluation

Given the significant relationship between these factors and the existence of a nutrient impairment, the Protocol should be withdrawn to allow for a more thorough evaluation of these well-recognized factors influencing nutrient dynamics in streams.

c. The Protocol failed to include key datasets in the public record

An essential tenet of administrative law is that the general public must be provided notice and an opportunity to comment on the bases for decisionmaking**.** *See, e.g., Nat'l Ass'n of Clean Water*

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[4] *See also generally Leather Industries of Am. v. EPA*, 40 F. 3d. 392 (D.C. Cir 1994), for the proposition that an agency assumption is not the same as having data or analysis to support a proposition and *Columbia Falls Aluminum Co. v. EPA*, 139 F.3d 914 (D.C. Cir. 1998) for the principle that EPA is not authorized to make regulatory decisions on "generalizations" when the case specific facts indicate that the generalized approach is inappropriate.

Agencies v. EPA, 106, 734 F.3d 1115, 1148 (D.C. Cir. 2013) (purpose of notice-and-comment provisions is "to ensure that affected parties have an opportunity to participate in and influence agency decision making at an early stage, when the agency is likely to give real consideration to alternative ideas."). Stated differently, at the outset of the comment period, the public must be provided with all the documents, data, and evaluations that served as the agencies' basis for an action. *See Citizens to Preserve Overton Park, Inc. v. Volpe*, 401 U.S. 402, 420 (1971) ("That review is to be based on the full administrative record that was before the Secretary at the time he made his decision."); *Environmental Defense Fund v. Blum*, 458 F. Supp. 650, 661 (D.D.C. 1978) (finding the agency "may not, however, skew the 'record' for review in its favor by excluding from that 'record' information in its own files which has great pertinence to the proceeding in question.").

As it pertains to this proposed Protocol, the Department's notice did not provide the public with access to the key data that constituted DEP's basis for developing the nutrient benchmarks (*e.g.*, 0.06 mg/L TP and 2.6 mg/L TN). Noting the absence of this information, H&A requested the missing data on November 3, 2015. A full week later, and just days before the comment deadline, on November 10, 2015, DEP provide H&A with the requested data set. (See, Attachment 2 – November 16, 2015 Email Chain: Kime to Kirby). Despite recognizing the fact that the data set was "used to derive the 0.06 mg/l phosphorous and 2.6 mg/l total nitrogen," the Department did not include the information in its initial proposal and public notice. Accordingly, the Protocol must be re-proposed to allow the public an opportunity to provide thorough comments on this critical data as well as the underlying evaluation of that information. *In re Amoco Oil Co.,* 4 E.A.D. 954, 980-981 (EAB 1993) (EPA improperly excluded analyses necessary for commenters to make informed comment); *Connecticut Light & Power Co. v. Nuclear Regulatory Com.*, 673 F.2d 525, 530 (D.C. Cir. 1982) ("To allow an agency to play hunt the peanut with technical information, hiding or disguising the information that it employs, is to condone a practice in which the agency treats what should be a genuine interchange as mere bureaucratic sport.").

d. Protocol should be submitted through formal WQS adoption process

DEP has the primary responsibility for the development and revision of water quality standards ("WQS") (both numeric and narrative) and the methodology for implementing these standards in Pennsylvania waters. 33 U.S.C. § 1313 et. seq.; 25 Pa. Code § 93.7(c); 40 C.F.R. § 131.4(a). Beyond ordinary notice and comment, adoption and revision of these standards and associated implementation methodologies, must undergo their own separate rulemaking procedures. 40 C.F.R. § 131.20(a),(b) & (c); 40 C.F.R. § 131.13; 71. P.S. § 510-20(b); *Simpson Tacoma Kraft Company v. Department of Ecology*, 835 P.2d 1030 (Wash. 1992) (development of a numeric criterion under the state's narrative criteria was required to go through public notice and comment).[5] For one, in Pennsylvania, all new or revised water quality standards must be

[5] DEP may not escape such requirements by titling the document as "guidance" or a "policy statement." Under state law, when DEP changes a regulation through a new interpretation of that regulation, it must do so in accordance with the Commonwealth Documents Law. *Hillcrest Home, Inc. v. Commonwealth*, 553 A.2d 1037, 1041 (Pa. Commw. 1989) (attempt to make a substantive change to a regulation via a "clarification" is improper); *see also Giant Food Stores,*

subjected to EQB review. *See* "About the EQB" website ("The Environmental Quality Board (EQB) is a 20-member independent board that adopts all of the Department of Environmental Protection's regulations.").[6] Second, all new and revised WQSs, including narrative criteria implementation methods, are subject to EPA review and approval. 40 C.F.R. § 133.13; 40 C.F.R. § 131.21.

In this case, the Department's proposed Protocol for evaluating nutrient impairments constitutes a revised WQS. This is because the Protocol establishes specific numeric thresholds that determine whether or not a stream is nutrient impaired. *See*, *United States Environmental Protection Agency Determination on Referral Regarding Florida Administrative Code Chapter 62-303, Identification of Impaired Surface Waters, July 6, 2005* at 9 (emphasis added) ("Provisions that affect attainment decisions made by the State and that define, change, or establish the level of protection to be applied in those attainment decisions, affect existing standards implemented under section 303(c) of the Act. *These provisions constitute new or revised water quality standards.*"); *Florida Public Interest Research Group Citizen Lobby, Inc. v. U.S. Environmental Protection Agency,* 2007 U.S. Dist. LEXIS 84039 (N.D. Fla. 2007).[7] The Protocol does not afford DEP personnel and discretionary judgment. That is, under the protocol, the stream is either nutrient impaired or not; there is no maybe. Consequently, because the Protocol establishes how the state will interpret the narrative standard for nutrients, it must be adopted pursuant to state and federal WQS rulemaking procedures.

Inc. v. Commonwealth of Pennsylvania, Department of Health, 713 A.2d 177 (Pa. Commw. 1998) (agencies may not employ unadopted regulations or guidance as mandatory requirements); *Department of Environmental Resources v. Rushton Mining Company*, 139 Pa. Commw. 648, 591 A.2d 1168 (1991).

[6] Available at available at http://www.dep.pa.gov/PublicParticipation/EnvironmentalQuality/Pages/WhatIsEQB.aspx#.VktKkV4-XYG

[7] *See also* U.S. Environmental Protection Agency, Water Quality Standards Handbook, Second Edition, EPA 823-9-94-005a (August 1994), ¶4 at 3-22 ("Where a State elects to supplement its narrative criterion with an accompanying implementing procedure, it *must formally* adopt such a procedure as a part of its water quality standards. The procedure *must* be used by the State to calculate derived numeric criteria that will be used as the basis for all standards' purposes, including the following: *developing TMDLs*, WLAs, and limits in NPDES permits . . . ." (emphasis added.); *see also* EPA's "Alaska Rule" governing adoption and modification of state water quality standards – 40 C.F.R. § 131.21, 65 Fed. Reg. 24641, 24647 (April 27, 2000) ("During the adoption of the detailed procedures, all stakeholders and EPA have an opportunity to make sure that important technical issues or concerns are adequately addressed in the procedures. *** This approach is particularly useful for criteria which are heavily influenced by site-specific factors such as nutrient criteria or sediment guidelines. Such procedures must include a public participation step to provide all stake-holders and the public an opportunity to review the data and calculations supporting the site-specific application of the implementation procedures.").

General Technical Observations

- **Cause and Effect Analysis Missing**

In 2010, EPA's Science Advisory Board ("SAB") peer reviewed draft guidance on the use of stressor-response relationships for development of numeric criteria for nutrients. The SAB's final report, SAB Review of Empirical Approaches for Nutrient Criteria Derivation[8], provided critical information and guidance concerning the factors that need to be considered when attempting to relate nutrients to aquatic life metrics using stressor-response relationships as PADEP claimed to do in developing their Protocol.

The Protocol, akin to a criterion, attempts to relate aquatic life metrics (Hilsenhoff Biotic Index (HBI), macroinvertebrate IBI) and certain stream metrics (DO flux) to nutrient concentrations using the same types of analyses addressed by the 2010 SAB. Consequently, the cautions identified by the SAB are directly relevant to the development of this nutrient impairment assessment tool. Several of these cautions are highlighted below.

> Without a mechanistic understanding and a clear causative link between nutrient levels and impairment, there is no assurance that managing for particular nutrient levels will lead to the desired outcome. (SAB Report at 6, first paragraph).
>
> Single variable stressor-response relationships (e.g., those derived using the simple linear regression approach discussed in the Guidance) that explain a substantial amount of variation are likely to be uncommon for most aquatic ecosystems (in particular, streams). (SAB Report at 12, second bullet).
>
> [r]elationships for streams may be more complex than for lakes and must account for multiple stressors/conditions and/or stream 'types' or conditions, and then be applied appropriately. (SAB Report at 25, first bullet).
>
> For criteria that meet EPA's stated goal of "protecting against environmental degradation by nutrients," the underlying causal models must be correct. Habitat condition is a *crucial consideration* in this regard (e.g., light [for example, canopy cover], hydrology, grazer abundance, velocity, sediment type) that is not adequately addressed in the Guidance. Thus, a major uncertainty inherent in the Guidance is accounting for factors that influence biological responses to nutrient inputs. Addressing this *uncertainty requires adequately accounting for these factors* in different types of water bodies. (SAB Report at 38, first bullet) (Emphasis supplied).
>
> Numeric nutrient criteria developed and implemented without consideration of system specific conditions (e.g., from a classification based on site types) can lead to management actions that may have negative social and economic and unintended

[8] EPA-SAB-10-006. April 27, 2010. Available on line at: http://yosemite.epa.gov/sab/sabproduct.nsf/E09317EC14CB3F2B85257713004BED5F/$File/EPA-SAB-10-006-unsigned.pdf.

> environmental consequences without additional environmental protection. (SAB Report at 38, third bullet).

The SAB emphasized the importance of establishing biologically significant stressor-response relationships while accounting for confounding factors. Based on these comments, EPA subsequently modified and finalized guidance on *Using Stressor-Response Relationships to Derive Numeric Nutrient Criteria* ("Stressor-Response Guidance"). EPA's final guidance incorporated all of the above SAB's observations. The Stressor-Response Guidance (cited by DEP) explains the mechanisms through which nutrients (*i.e.*, stressor) adversely affect aquatic life (*i.e.*, response):

> …one of the more important pathways by which nutrient enrichment affects designated uses in streams is by *increasing primary productivity*. (Stressor-Response Guidance at 11) (Emphasis supplied).

> Nitrogen/phosphorus pollution generally does not typically exert direct adverse effects on higher trophic levels (e.g., fish and invertebrates). However, indirect effects of nutrient enrichment affects aquatic life at these higher trophic levels through a number of different pathways, including reduced physical habitat quality, decreased *dissolved oxygen concentrations*, alterations to food quantity and quality, and *increased nuisance plant and algae growth* that may increase algal toxins and reduce food quality. (Stressor-Response Guidance at 13; Emphasis supplied).

Regarding confounding factors, the Stressor-Response Guidance also asserts "many confounding variables *must be considered* when estimating the effects of nitrogen/phosphorus pollution on a measure of aquatic life in streams (e.g, a macroinvertebrate index)." (Stressor-Response Guidance at 11).

The Protocol references EPA's "Stressor Response Guidance" as the basis for the analyses presented. However, by ignoring primary productivity, plant growth, DO concentration, and any consideration of confounding factors, the Protocol does not adhere to the Stressor-Response Guidance and therefore, the resulting stressor-response relationships upon which the Protocol is based are not scientifically defensible. This critical deficiency can only be cured by completing the necessary analyses needed to ensure stressor-response relationships are "scientifically defensible", as required by state and federal law. (See, *e.g.*, 40 CFR §130.6, §130.10).

- **Conceptual Model Unverified and Misapplied**

Figure 1 below illustrates the conceptual model upon which the Protocol is reportedly based (Protocol at 4).

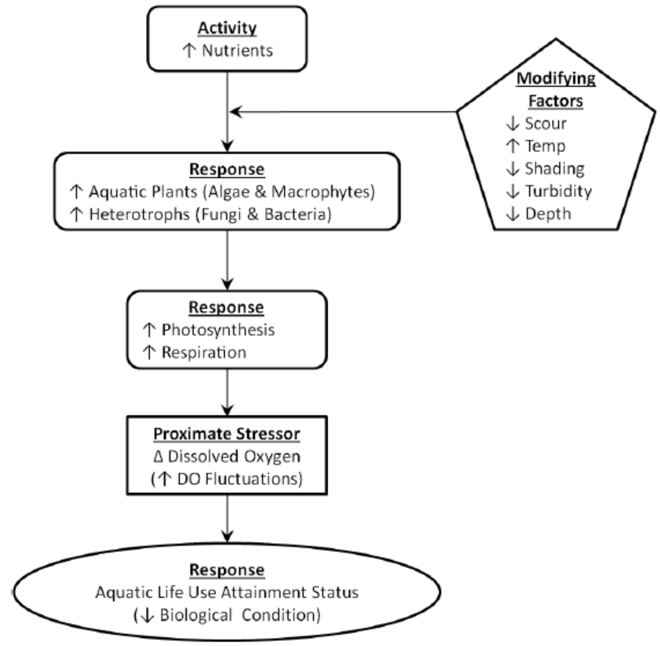


Figure 1. Conceptual Model Used in the Development of PADEP's Nutrient Impact Assessment Protocol.

The Background Report's more detailed conceptual model in Figure 1 (at 4) and the simplified model above, illustrating the basis for the Protocol (Figure 2; at 5; also Protocol Figure 1 at 4), are predicated on a presumed stressor-response relationship between ALU attainment status and dissolved oxygen fluctuation. No analyses or data presented in the Protocol or the supporting document demonstrate such a relationship. Moreover, none of the cited bibliography materials present any confirmation of this relationship. Aquatic life uses, as characterized by benthic macro-invertebrates, are known to respond to minimum DO thresholds but not to DO fluctuation absent excursions of the minimum DO water quality standard.

In this regard, the Protocol appears to be inconsistent with the basis for its foundation. The Introduction to the Protocol includes the following assertion:

> Increased productivity of heterotrophic microbes and aquatic plants modifies rates of photosynthesis and respiration, and can lead to wide diel fluctuations in dissolved oxygen (DO) concentrations, low DO levels, and an overall shift to biological communities that are more tolerant of low DO conditions (Miltner and Rankin, 1998; Dodds and Welch, 2000; Slavik et al., 2004; Miltner, 2010; Yuan, 2010). (at 3)

The shift in biological communities that is the focus of the ensuing analyses is due to "low DO conditions", *not* DO fluctuation. (See, Attachment 1 - FOIA Request and Response, EPA-HQ-009040) However, no data are provided concerning minimum DO concentration. The only assessment is based on the magnitude of the DO flux, which is not the cause of impairment.

Moreover, the modifying factors identified in Figure 1 of the Protocol (*i.e.*, scour, temperature, shading, turbidity, depth) are also factors that directly influence benthic macroinvertebrate aquatic life. These and numerous other non-nutrient factors influence benthic macroinvertebrates, but are not further considered in the conceptual model, contrary to the SAB and Stressor-Response Guidance admonitions. As a consequence, this approach is certain to mis-identify streams as nutrient impaired and divert resources to nutrient control when such control is incapable of restoring designated uses because the cause is something other than nutrients.

Specific Technical Observations

1. **No Assessment of Plant Growth**

The Protocol explains the conceptual model's "complex series of relationships" where each response is caused by the preceding stressors. A key component of the conceptual model is:

> [i]ncreased productivity of heterotrophic microbes and *aquatic plants modifies rates of photosynthesis and respiration*, and *can* lead to wide diel fluctuations in dissolved oxygen (DO) concentrations, low DO levels, and an overall shift to biological communities that are more tolerant of low DO conditions. (at 3; internal citations omitted; emphasis added).

Nutrients *can* stimulate plant growth which *can* alter diel DO flux resulting in low instream minimum DO concentrations, *possibly* adversely affecting HBI and aquatic life. However, nutrients are, in and of themselves, non-toxic and do not directly affect HBI, diel DO flux, or aquatic life. Moreover natural conditions may exist which prevent the manifestation of nutrient impacts or simulate similar "impacts". While including assessments of nutrients, HBI, and diel DO range, the Protocol ignores the integral step of assessing the degree of plant growth, *the only factor that directly responds to nutrients*. The absence of analysis of plant growth undermines the conceptual model, skipping two of the four essential response groups required to link increased nutrients to aquatic life use impairment. The more detailed conceptual model in the Background Report (at 4) links nutrients to aquatic life use through multiple plant growth-related mechanisms: 1) primary productivity (algal biomass), 2) organic matter (algal biomass), 3) nuisance plants/algae (algal biomass), 4) food quality (algal type and biomass), and 5) algal toxins (algal type and biomass). Quantification of any of these mechanisms requires an assessment of plant growth. In accordance with the conceptual models, there can be no scientifically valid determination that nutrients are adversely affecting the water body unless plant growth is assessed and, at a minimum, demonstrated to be significantly greater than upstream conditions. This is essential as, explained later, as DEP's database included many sites with major urban influences that are well-known to influence the type of invertebrates that may be present. DEP itself determined that Paxton Creek's reduced invertebrate population was a function of these other factors, not the elevated nutrients present in those waters. (See, 2012 Delisting of Paxton Creek). The failure to consider these factors in developing the Protocol is inexplicable.

The SAB expressly rejected assessment methodologies which do not demonstrate linkages between causal variables and biologically significant responses:

> Without a mechanistic understanding and a *clear causative link between nutrient levels and impairment,* there is *no assurance* that managing for particular nutrient levels will lead to the desired outcome. There are numerous empirical examples where a given nutrient level is associated with a wide range of response values due to the influence of habitat, light levels, grazer populations and other factors. If the numeric criteria are not based upon well-established causative relationships, the scientific basis of the water quality standards will be seriously undermined. (SAB at 6; emphasis added).

Thus, absent clear causative links between nutrients levels and impairment (*i.e.*, a significant increase in plant growth due to nutrients (not habitat changes)), there can be no assurance that the Protocol can achieve its reported goal of determining whether nutrients are a cause of ALU impairment.

2. Diel DO Thresholds Do Not Constitute Impairment

The Protocol explains, "[t]his model focuses on *diel DO fluctuations* as the proximate stressor *ultimately affecting stream biological conditions in response to nutrient enrichment*." (at 3; Emphasis supplied). Diel DO range, the metric used in the second tier of assessment and listed as a proximate stressor in the conceptual model, is an inappropriate indicator of impairment to aquatic life use, and in particular, invertebrates. The diel DO range does not, in and of itself, adversely affect aquatic life as claimed by the Protocol. Rather, minimum DO concentrations negatively affect aquatic life as is well demonstrated by the published federal Section 304 criteria documents for DO (*e.g.*, 1986 Freshwater DO Criteria).

In response to a 2014 Freedom of Information Act ("FOIA") request, EPA Headquarters confirmed that diel DO range has never been approved as an aquatic life use impairment metric.[9] In its response to this FOIA, EPA only cited to USEPA's 1986 *Quality Criteria for Water* ("Gold Book")[10] as the scientifically defensible basis for finding a DO-related impairment. The Gold Book lists DO criteria as mean and minimum values representing "the best science available" with no diel DO range criteria.

Whether or not a particular diel DO variation will cause a sufficiently low minimum DO to occur cannot be determined from the analyses presented. It is certainly possible for streams to exhibit diel DO ranges exceeding the Protocol's benchmark values but maintain minimum DO concentrations supportive of aquatic life. Additionally, any assessment of the conceptual model linking nutrients to algal growth to DO must consider those non-nutrient factors that influence instream DO concentration. Examples of these confounding factors include upstream DO variability, water depth, temperature, hydraulic slope, substrate, and flow.

In Figure 14 (at 24) of the Background Report, the Category 1 (ALU attaining, tier 1 screening passed) data exhibit diel DO ranges exceeding the benchmark values in each season. At a

[9] See Attachment 1 - FOIA Request and Response EPA-HQ-009040.
[10] Available at http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/upload/2009_01_13_criteria_goldbook.pdf

minimum, this demonstrates that aquatic life uses are not adversely affected at the observed diel DO fluxes. Assuming that diel flux is a relevant metric, the data indicate that the threshold must be a value greater than those selected. The SAB final report notes that "response variables must in all cases have biological relevance and be associated with designated uses." (at 30). As illustrated in Figure 14 from the Background Document, the diel flux selected as the threshold for assessing the cause of use impairment is not substantiated.

In summary, diel DO range is inappropriate as a screening metric and it is recommended that minimum DO be assessed instead, especially if continuous DO monitoring will be required after failing the Tier 1 screening.

3. Nutrient-Invertebrate Stressor-Response Analysis Misleading

In general, stressor-response evaluations attempting to link nutrient concentration to macroinvertebrate metrics have repeatedly failed to identify any useable relationship. For example, in Florida, EPA attempted to develop numeric nutrient water quality standards linking nutrient to invertebrates. However, after years of data collection and statistical analyses using a very robust data set, EPA was unable to demonstrate statistically significant and biologically relevant relationships between nutrients and invertebrates. R^2 values were typically less than 0.1 (*i.e.*, no meaningful relationship could be documented). It was determined by EPA that no predictive relationship between nutrients and invertebrate metrics could be derived as confounding variables significantly influenced this relationship. Even such analyses recently published by EPA for streams in Eastern Pennsylvania confirmed no meaningful relationship could be found. (See, technical support documents for the draft 2015 Wissahickon Creek TMDL).

Contrary to these findings, the Background Document presents similar correlation analyses with R^2 values in excess of 0.5. These results appear too good to be true and are, to a reasonable certainty, the results of (1) an improperly structured and biased dataset and (2) the failure to assess confounding factors occurring with the elevated nutrient levels. The reasons behind this "too good to be true" fit is examined briefly below and in greater detail in the section on Data Insufficient/Biased.

In Goose Creek, a stream cited in the Background Report, a TMDL attributed a macroinvertebrate impairment to nutrient impacts, confirms why the analyses produce an R^2 too good to be true. It is true that the sections of Goose Creek presented for analysis exhibit high nutrient levels. However, a GHD, Inc. study concluded that "all previous macroinvertebrate sampling and analysis shows that the in-stream habitat in the majority of the Goose Creek study reach is unsuitable for macroinvertebrate colonization" and,

> [a]ccording to the Goose Creek data, higher nutrients from WWTP discharges do not spur more plant growth, nor do they cause worse water quality, nor do they result in more impacted macrobenthos. Hence, the now-extensive sampling *data for Goose Creek provide no support for the first assumption underlying the TMDL; instead, the data lead*

> *to the conclusion that high levels of nutrients do not cause impairment of Goose Creek macrobenthos*. (at 8, 25; emphasis added).

Therefore, while elevated nutrients were found at these stations as well as low invertebrate levels, it is not the cause of the condition. Consequently, the relationships illustrated in Figure 4 and Figure 5 from the Background Report misrepresent the effect of nutrients on macroinvertebrates.

Likewise, Boulder Creek, in Colorado, was the subject of a 2015 WERF study to evaluate nutrient criteria development based on water quality modeling to predict the influence of nutrient loads on benthic algal growth, water quality (DO, pH), and benthic macroinvertebrates. Contrary to the findings in the Background Document, this study did not identify any adverse effects on macroinvertebrate diversity associated with nutrients or with benthic algal growth. Adverse effects on macroinvertebrates were only observed where pH variability exceeded a pH of 9.0 su (a condition occurring in the more alkaline waters far downstream in the open plains).

Finally, it is apparent that the regression analysis mixed stream fishery types (cold verse warm water fisheries). By itself, this renders the entire analysis useless since nutrient. Invertebrate assemblages and DO responses are dramatically different in these waters. Thus, it is apparent that the presented stressor-response analysis is not simply deficient, it is highly unreliable and contrary to the more detailed information that was available to confirm its efficacy.

4. Confounding Factors Controlling/Influencing Invertebrate Metrics Not Assessed

The Protocol concedes that confounding (or modifying) factors can result in conditions where:

> […] elevated nutrient levels may, *or may not*, *affect the photosynthesis, respiration, and dissolved oxygen* characteristics of the waterway to *a degree that ultimately results in non-attainment of aquatic life use* (ALU). (at 8; emphasis added).

While acknowledging the potential for mischaracterizing the impact of nutrients, the Protocol then ignores such possibilities and includes no assessment of confounding variables. However, the stressor-response evaluations used to support the Protocol development are not scientifically defensible without such an assessment as noted in the SAB Report.

> …require careful consideration of confounding variables before being used as predictive tools. […] Without such information, nutrient criteria developed using bivariate methods may be highly inaccurate […] In order to be scientifically defensible, empirical methods must take into consideration the influence of other variables. (2010 SAB at 24).

Accordingly, with no confounding factors analysis, the justification for the proposed Protocol lacks adequate support and needs to be reassessed using scientifically defensible methods. The failure to assess a key factor influencing a pollutant's impact or lack thereof, is a quintessential example of arbitrary and capricious action. See, *Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 43 (U.S. 1983).

5. TP Benchmark Unrelated to Algal Growth Control

The Protocol utilizes 0.06 mg/L TP and 2.6 mg/L TN as "screening benchmark values" above which nutrient impairment may be anticipated. Repeated studies and reports have concluded that benthic algae can grow to excessive levels in response to very low levels of phosphorus. Zou *et al.*, 2006 concluded that it was infeasible to control periphyton in Wissahickon Creek through reducing nutrient load from point sources because periphyton only need a very low concentration of phosphorus (about 0.010 – 0.015 mg/L) to support its growth to very high levels.[11] Similar observations have been made by Dodds (2006)[12], Hall and Hall (2009)[13], Suplee (2012)[14], and Chapra *et al.* (2014).[15] Site-specific studies in Southeastern PA watersheds also confirmed this was true (Carrick, 2005[16]; Paul and Zheng, 2007[17]; Kleinfelder, 2014[18]; GHD, 2015[19]). Regarding the efficacy of this Protocol, these findings support two important realities: (1) if background concentrations exceed this level, plant growth cannot be controlled by nutrient reduction, and (2) the nutrient concentration necessary to control plant growth is much lower than the screening benchmark values.

In Indian Creek, a stream cited in the Background Report, Kleinfelder, Inc. (2014) sampled phosphorus concentrations and periphyton, taking note of the percent shaded at each location, in September 2014. During the periphyton survey, periphyton levels of 300-335 mg/m^2 chl-a were observed for TP concentrations in a range of 0.10-0.24 mg/L, which included areas with no significant point sources. At the remaining survey sites, higher periphyton levels between 490-825 mg/m^2 chl-a were observed for TP concentrations in a slightly lower range of 0.06-0.18 mg/L. The report concluded that "[n]o relationship between phosphorus concentration and periphyton density was detected in the Indian Creek watershed." (at 13). Watershed data collected upstream of the wastewater discharges confirmed average nutrient concentrations in the

[11] Zou, R., S. Carter, L. Shoemaker, A. Parker, and T. Henry. 2006. Integrated Hydrodynamic and Water Quality Modeling System to Support Nutrient Total Maximum Daily Load Development for Wissahickon Creek, Pennsylvania. Journal of Environmental Engineering. April 2006. 555-566.

[12] Dodds, W. 2006. Eutrophication and trophic state in rivers and Streams. Limnol. Oceanogr. 51(1, part 2): 671-680. "[A]ttached algae might be able to attain impressive biomass in nutrient-poor water because periphyton can use the small amounts of nutrients that continuously flow by." At 677.

[13] Hall, J.C. and W.T. Hall. (2009). Critical Evaluation of EPA Stream Nutrient Standard Initiatives. BNA Environmental Reporter: July 3, 2009, pp 1-17.

[14] Suplee, M.W., Watson, V., Dodds, W.K., and C. Shirley. (2012). Response of Algal Biomass to Large-Scale Nutrient Controls in the Clark Fork River, Montana, United States. Journal of the American Water Resources Association: 48; 5, pp 1008-1021.

[15] Chapra, S., K. Flynn, and J. Rutherford. 2014. Parsimonious Model for Assessing Nutrient Impacts on Periphyton-Dominated Streams. J. Environ. Eng., 140(6), 04014014. This paper presents a method for evaluating nutrient criteria necessary to meet a maximum periphyton biomass. As an example, the phosphorus concentration necessary to limit periphyton growth to 150 mg chl-a/square meter is 3 μg/L. At 11.

[16] Carrick, H.J. and C.M. Godwin. (2005). TMDL endpoint estimates for a urban-suburban stream based upon in-stream periphyton assemblages (Neshaminy Creek, Pennsylvania).

[17] Paul, M. and L. Zheng. November 20, 2007. Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application.

[18] Kleinfelder Inc. (2014). Technical Report: Indian Creek Watershed Periphyton Density and Phosphorus Concentration Survey.

[19] GHD Inc. (2015). 2014/2015 Goose Creek Reassessment.

range of 0.060 – 0.080 mg/L TP. Consequently, even where point sources were absent, the ambient TP concentration did not limit algal growth. Thus, the Protocol's benchmark of 0.06 mg/L TP has no apparent applicability to Indian Creek and cannot be used as a nutrient threshold indicative of aquatic life use attainment/impairment. Instead, Kleinfelder suggested that light availability accounts for some degree of periphytic growth.

In Goose Creek, a stream cited in the Background Report data, a GHD Inc. (2015) study assessed the cause of aquatic life use impairment identified in a TP TMDL issued by EPA. The study assessed habitat, macroinvertebrate metrics, diel DO, plant growth, and nutrient data, among others. Data indicated that total phosphorus downstream of the WWTP averaged around 17 times higher than upstream conditions (approximately 1.34 mg/L vs. 0.08 mg/L). However, the macroinvertebrates metrics clearly improved downstream of the WWTP. Furthermore, the report asserted "[p]eriphyton biomass, as measured by PaDEP's methods, does not show any apparent relationship to phosphorus levels." (at 24). The study concluded that the TP TMDL rationale was in error:

> In summary, other than the fact that phosphorus concentrations are elevated downstream of the WWTPs, the sampling data do not support any of the necessary conditions in the causal chain of events from high nutrients to impacted benthos. According to the Goose Creek data, higher nutrients from WWTP discharges do not spur more plant growth, nor do they cause worse water quality, nor do they result in more impacted macrobenthos. Hence, the now-extensive sampling data for Goose Creek provide no support for the first assumption underlying the TMDL; instead the data lead to the conclusion that high levels of nutrients do not cause impairment of Goose Creek macrobenthos. The allied assumption underlying the TMDL – reductions of nutrient will produce un-impacted macrobenthos – is also clearly but more simply disproved. (at 24-25).

Instead, the GHD report suggested:

> However, other ecological evidence suggests that the macrobenthos community may respond negatively to lower chloride concentrations than those associated with direct toxicity to macrobenthos (e.g., see Morgan et al., 2007). As further evidence for this potential impact in Goose Creek, chloride levels are highest upstream, where the macrobenthos showed the greatest level of impairment. (at 20).

The GHD report also cites to three previous Gannet Fleming Stream Studies (1999, 2008, and 2011/2012) which all concluded non-nutrient metrics caused the macroinvertebrate impairment in Goose Creek (at 7-8).

Other researchers have reported similar results. Kiffney and Bull (2000)[20] evaluated periphyton accrual during the summer in headwater streams with natural TP levels below 0.002 mg/L. Streams with open canopies exhibited periphyton biomass up to 190 mg chlorophyll-a/m^2. Closed canopy sites experienced significantly lower periphyton biomass. Bourassa and Cattaneo

[20] Kiffney, P. and J. Bull. 2000. Factors controlling periphyton accrual during summer in headwater streams of Southwestern British Columbia, Canada. Journal of Freshwater Ecology. 15(3).

(2002)[21] studied the effect of nutrient manipulation in a lake outlet stream in Montreal, Quebec. They reported that the effect of nutrient enrichment (from 0.007 – 0.021 mg/L TP to 0.017 – 0.088 mg/L TP) was not detectable, although benthic algal growth was, on average, three times less in shaded channels. This would indicate that benthic algal growth was already saturated at the lower concentrations. Hill and Fanta (2008)[22] evaluated periphyton growth rates in large flow-through laboratory streams. They reported that periphyton growth rates plateaued at soluble reactive phosphorus ("SRP") concentrations in excess of 0.022 mg/L, suggesting that nutrient SRP criteria ≥ 0.025 mg/L will have virtually no effect on controlling periphyton growth. These researchers also noted that the effect of light availability was much stronger than the effect of phosphorus concentration. While changes in SRP concentration increased growth two-fold over a concentration range of 0.005 – 0.300 mg/L, the effect of light exhibited a ten-fold increase in periphyton growth. In yet another study, installation of biological nutrient removal ("BNR") at the City of Waynesboro, VA WWTP resulted in significant TP reduction in the South River (a tributary to the Shenandoah-Potomac River system and a major tributary to the Chesapeake Bay) below the outfall (from 0.5 mg/L to 0.03 mg/L).[23] Although the instream TP concentration was less than the TP benchmark used in the Protocol, benthic algal surveys of the river showed no change in algal growth (consistent with the other results reported in the literature).

In short, there is no available information presented in the Protocol showing that assessing TP (or TN) at the recommended level represents a threshold in the causal pathway. The available detailed studies (not considered in the Protocol), including studies conducted in wadeable Pennsylvania streams, certainly confirm it will not. Consequently, the selected benchmarks and the statistical analyses used to support their development bear no meaningful scientific relationship to aquatic life use attainment. Even if none of the Tier 1 benchmark values were triggered (concluding nutrients are not a cause of ALU impairment), high algal growth may likely still occur. Because the selected TP benchmark does not limit periphyton growth and even background nutrient concentrations frequently exceed this level, its use as an indicator of nutrient impairment is not scientifically defensible.

6. Nitrogen Typically Not Limiting Nutrient in Freshwaters

The Protocol assesses instream total nitrogen concentrations against a benchmark value in Tier 1. However, there is no literature presented showing that TN control would be expected to be necessary to address excessive plant growth. The "law of the minimum" applies to determine which, if any, nutrient may be controlled to reduce plant growth. The data referenced (Suplee) confirm that unbounded plant growth occurs even at a 0.3 mg/L TN concentration. The use of this metric is inappropriate as TP, not TN, is typically the limiting nutrient in freshwaters. All prior EPA TMDLs for Pennsylvania streams determined that only TP reduction would be

[21] Bourassa, N. and A. Cattaneo. 2002. Response of a lake outlet community to light and nutrient manipulation: effects on periphyton and invertebrate biomass and composition. Freshwater Biology. 44: 629 – 639.
[22] Hill, W. and S. Fanta. 2008. Phosphorus and light colimit periphyton growth at subsaturating irradiances. Freshwater Biology 53: 215-225.
[23] Brent, R., R. Morland, D. Berberick, S. Davis, B. Foltz, and K. Drummond. 2014. Mercury falling. How a facility upgrade intended to reduce algae growth resulted in unintended (yet favorable) consequences. Water Environment and Technology. August 2014. 62 – 65.

scientifically defensible. Consequently, the Tier 1 threshold for TN is likely to inappropriately identify receiving streams as nutrient-impaired.

7. Data Insufficient/Biased Inadvertently Influenced the Regression Analyses

The dataset used in the development of the Nutrient Impact Assessment Protocol appears biased. These data are summarized in Tables 1, 2, and 3 of the Background Report. The Protocol assessed only 40 samples from 33 stations on 27 streams. The State, however, sampled more streams and more stations for more years than the included data. The justification for selecting these stations during specific years is not clear from the Protocol or Background Report. Given that the Protocol will apply to all wadeable streams, it would be inappropriate to assess such a small subset of streams in Pennsylvania for the derivation of the Protocol but then apply the results to the entire State, including the excluded streams, and expect predictable results.

Moreover, the limited dataset used to derive the proposed Protocol inappropriately combines multiple stream types (cold and warm water fisheries, which affects invertebrate metrics) without appropriately classifying the streams as recommended in the EPA Stressor-Response Guidance. The effect of inadvertently mixing datasets with drastically different physiological conditions in developing regression analyses and reaching certain conclusions regarding the effect of nutrient levels on stream health is discussed in greater detail below.

a. Biased Data

Stressor-response evaluations are presented as linear regressions of the response metrics (macroinvertebrate IBI, HBI, diel DO range) versus maximum TP and maximum TN concentration. (See, Background Report, Table 4 at 11 and associated Figures) These evaluations present coefficients of determination (R^2 values) that range from 0.36 to 0.65 with probabilities <0.001. The indicated R^2 values are much better than the corresponding values reported by USEPA in its Stressor-Response Guidance or other states for this type of assessment. Consequently, how such unusually good results were achieved where all others have failed is an issue that must be explored in detail.

A more thorough evaluation of the data shows that these unexpectedly good results can be attributed to use of a limited dataset which includes streams from markedly different habitat types and classifications. The streams with attaining macroinvertebrate indices tend to be cold water fisheries with very little human disturbance and low nutrient levels. The streams not attaining macroinvertebrate indices tend to be warm water habitats with significant human disturbance and high nutrient levels. If the data were properly classified, the apparent relationship illustrated in the Background Report would dissolve (as has occurred in the analyses performed by others) and be shown to be a function of habitat, as illustrated below.

b. Classification

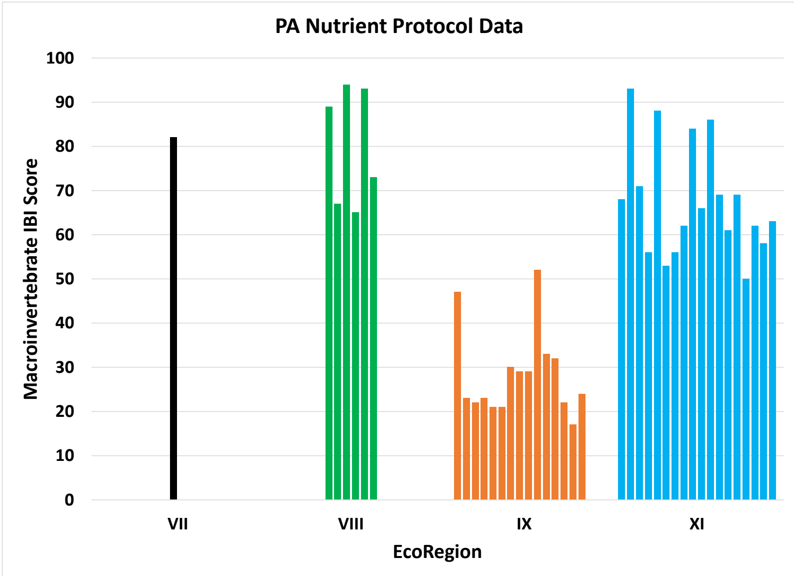
As described in the Background Report, PADEP used a stressor-response approach to develop the proposed Protocol (Background Report at 23). The use of such approaches is discussed in

USEPA's guidance document (USEPA, 2010), which is referenced in the Background Report. The USEPA guidance provides specific recommendations concerning how stressor-response relationships should be developed.

> When using stressor-response relationships to derive criteria, the estimated relationships should represent the relationships shown on the conceptual model as accurately as possible. However, in most cases other environmental variables may influence, or confound, bivariate relationships estimated between a nutrient and a response variable. Hence, in the first step of the analysis, *classification*, the analyst attempts to control for the possible effects of other environmental variables by identifying classes of waterbodies that have similar characteristics and are expected to have similar stressor-response relationships. Classifications for a stressor-response analysis are typically based on statistical analysis; however, existing classes can be used as a starting point. The most widely used existing classifications for analyses of nutrient data are the fourteen national nutrient ecoregions (Omernik et al. 2000, USEPA 2000a). These ecoregions were designated based on similar climate, topography, regional geology and soils, biogeography, and broad land use patterns. In addition to ecoregions, other qualitative groupings may be readily available (e.g., deep versus shallow lakes). Existing and qualitative classes provide a coarse starting point that should be refined as the analysis proceeds.

(USEPA, 2010 at 32) (Emphasis supplied)

No attempt was made to classify the data from the various streams which exhibit distinct habitat differences influencing the invertebrate metrics. Had such classification been conducted, it would be readily apparent that multiple confounding factors are present in the dataset that preclude establishing a single (reliable) governing relationship between the multiple response variables and nutrients. For example, Table 2 from the Background Report identifies the various Ecoregions identified by USEPA. If the macroinvertebrate IBI scores from Table 3 of the Background Report are plotted by Ecoregion, it is apparent that the response is primarily a function of Ecoregion, as illustrated below.



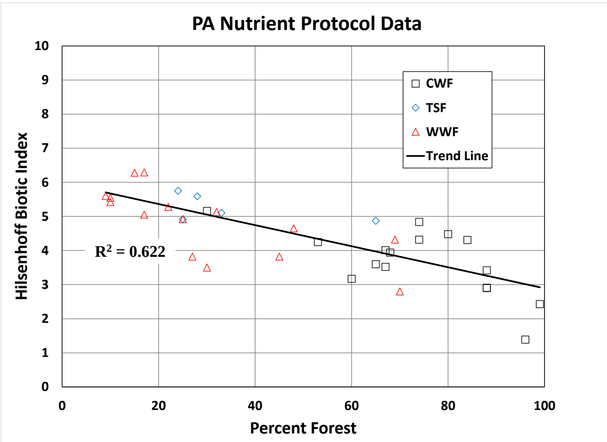
Since the individual Ecoregions represent areas of similar climate, topography, regional geology and soils, biogeography, and broad land use patterns, as noted in USEPA's guidance, these become confounding factors that must be properly assessed before any scientifically defensible relationship to nutrients can be evaluated. At first blush, however, it is quite clear that EcoRegion IX is quite different from the others – the question is why.

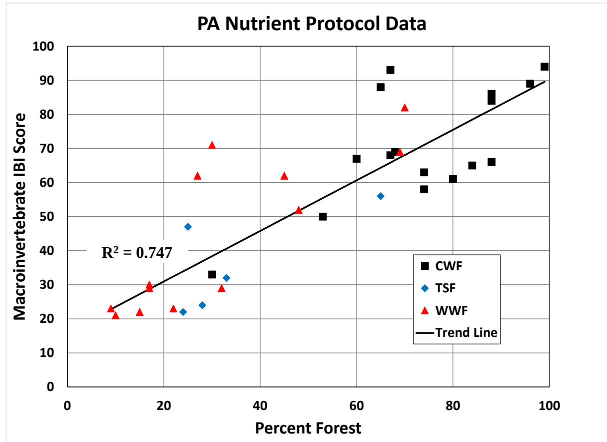
In addition, a review of the protected water use for each stream indicates that the streams include cold water fisheries, trout stock fisheries, and warm water fisheries. The attainment versus impairment status for these fisheries is skewed, with most attaining fisheries designated as cold water fisheries, as expected.

Protected Water Use	Use Attainment Status	
	Attaining	Impaired
Cold Water Fishery	9	5
Trout Stock Fishery	1	5
Warm Water Fishery	3	10

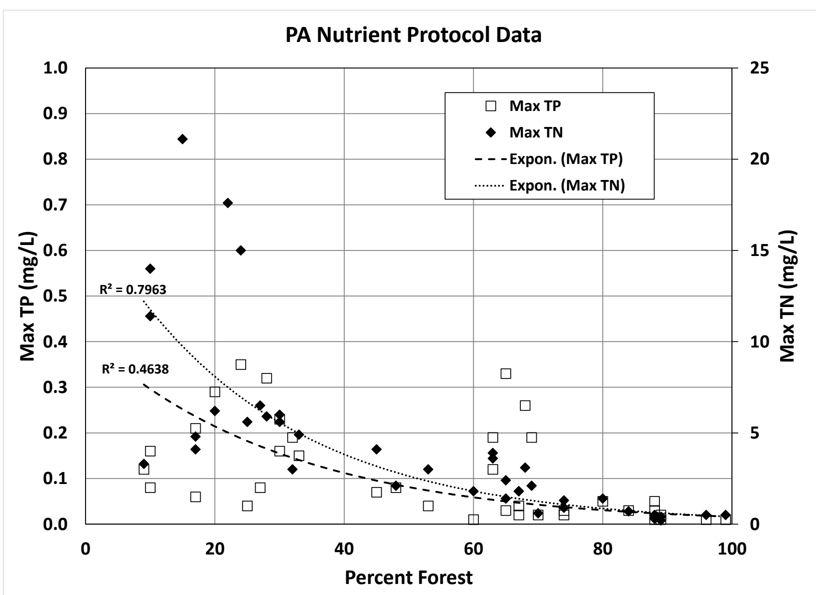
Based on the protected water use, we would expect significant differences among the stream types for water temperature, habitat, geology, current velocity, and water depth. Each of these factors has a significant effect on dissolved oxygen diel variability, algal growth, and macroinvertebrate metric. Moreover, these designations carry with them expected covarying differences in invertebrate populations, nutrient level, and non-nutrient human disturbance. These factors have not been independently evaluated and their confounding influence on the stressor-response evaluations presented in the Protocol have not been assessed. Consequently, there is no confidence that any of the evaluations reliably reflect a nutrient effect.

Table 2 from the Background Report provides information on the amount of development in each watershed. These metrics include the percentage of the land cover that is forested, urban, and impervious cover. A plot of the invertebrate metrics versus these land development metrics shows that stream attainment status is more highly correlated with these metrics than it is with nutrient concentration (*i.e.*, $R^2 = 0.62 – 0.75$). The plot of Hilsenhoff Biotic Index and Invertebrate IBI Score against percent forest cover shows the same strong correlation between deteriorating macroinvertebrate metric and decreasing forest cover.



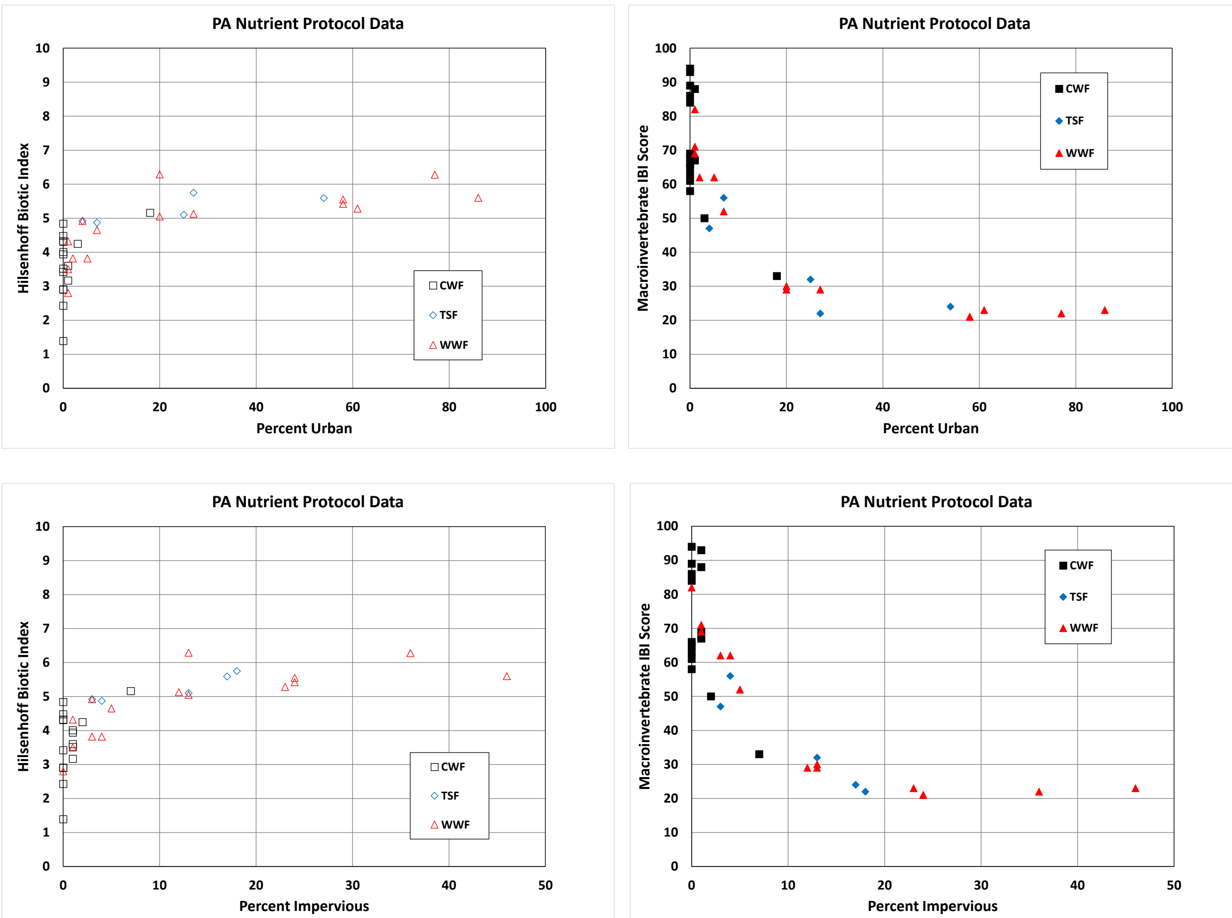


The nutrient level in virtually all of these waters are sufficient to allow unbounded plant growth. Consequently, it is apparent that other habitat factors are most likely controlling the invertebrate response. For example, as the forest cover decreases, stream flow becomes flashier and runoff transports greater amounts of sediment to the stream. These well-known factors adversely affect macroinvertebrates and need to be evaluated to account for the confounding effects associated with these characteristics before the cause of deterioration is attributed to nutrients. Moreover, when the protected use type is considered, it is apparent that best performing streams are cold water fisheries and poorest performing streams are warm water fisheries. The percent forest cover is also significantly correlated to the maximum nutrient concentration as illustrated below.



Since the maximum nutrient concentration is significantly correlated with forest cover and the biotic metric is also significantly correlated with forest cover, the stressor-response evaluations comparing biotic metric with maximum nutrient concentration is thoroughly confounded by the relation of maximum nutrient concentration to forest cover. Consequently, the stressor-response relationships upon which the Protocol was developed are simply unreliable.

The correlation between macroinvertebrate metric and percent urban characteristic of the drainage area or the impervious cover of the drainage area shows an even more significant relationship than that for forest cover. As illustrated below, as the urban area or impervious cover increases above 5 - 10 percent, the biotic indices fall sharply below the impairment thresholds, with the responses asymptotically approaching 6 (HBI) and 20 (IBI).



Consequently, it is apparent that the failure to consider the confounding factors, as recommended by the SAB and EPA's Stressor-Response Guidance renders this analysis fundamentally deficient for its intended purpose (*i.e.*, the identification of waters that are actually nutrient impaired).

c. Maximum Metrics Inconsistent with Conceptual Model

The Protocol focuses on maximum values for TP, TN, and diel DO range (Background Report at 12-15, 21-22). We are not aware of any accepted conceptual model for nutrient impairment that uses the maximum observed TP or TN concentration as the basis for assessing adverse impacts, as plant growth does not respond to the maximum concentration. Consequently, the *USEPA Nutrient Criteria Technical Guidance Manual – Rivers and Streams* (2000, EPA 822/B-00-002) only discusses seasonal or annual averages for assessing numeric nutrient criteria and the numeric nutrient criteria developed by USEPA for Florida streams were expressed as annual averages. All nutrient TMDLs developed by EPA for Pennsylvania streams also regulated on a growing season basis.

Moreover, this approach appears inconsistent with the conceptual model upon which the Protocol was developed. Nutrients *never* directly influence dissolved oxygen or macroinvertebrates. Rather, nutrients may stimulate plant growth if other conditions are appropriate. Once the level of plant growth changes, this may influence the range of dissolved oxygen flux that then influences the macroinvertebrate population. This model does not relate adverse effect on the proximate stressor (dissolved oxygen) to maximum nutrient concentration. Rather, there is an interval of time between exposure of the aquatic plant to the nutrient concentration and the growth of algal biomass that affects dissolved oxygen in the stream. The growth of algal biomass to excessive levels is a function of the average exposure to nutrient concentrations, not an instantaneous maximum concentration. Consequently, use of the maximum nutrient concentration as a Tier 1 metric in the proposed nutrient Protocol is fundamentally misplaced and not scientifically defensible.

d. Data Request Response Inconsistent with Background Document Analyses

The correspondence with Charles McGarrell (PADEP) and Rodney Kime (PADEP) provided the Excel file "ProtcolNumbers.xls" reportedly "used to derive the 0.6 mg/l phosphorous and 2.6 mg/l total nitrogen." (See, Attachment 2 – November 16, 2015 Email Chain: Kime to Kirby).[24] The spreadsheet includes data mostly from streams not listed in the Protocol or Background Report (*e.g.*, Lehigh River, Delaware River, Genesee River) and excludes all but four or five streams listed in the Background Report. This is inconsistent with the Protocol's claim that the streams in Table 1 of the Background Report "were used to develop the NIA Protocol." (Background Report at 6-7). The provided dataset is clearly not the dataset used in the Protocol and Background Report.

Furthermore, the numerical data presented in this file are the May to September average nitrogen and phosphorus concentrations, averaged over an unidentified period of years. While the basis for the benchmark values appears to be a growing season average, the benchmarks were applied as daily maximum values without any justification. The justification for omitting seven months of the year from the data analysis while the Protocol applies to nutrients year-round is not presented. These errors and inconsistencies render the public notice and comment process fundamentally flawed as the public was not provided with essential background data and analyses.

[24] Charles McGarrell also provided a spreadsheet entitled "Report Table 3 Nutrient Data.xls." This spreadsheet was used "to generate the max TP and TN values shown in Table 3" and Figures 4, 5, and 7 of the Background Report (See, Attachment 3 - November 12, 2015 Email Chain: McGarrell to Kirby). The maximum TP and TN data are calculated from as few as two data samples (*e.g.*, Towamencin Cr 2013) and as many as fifteen (*e.g.*, Frankstown Br 2014).

8. Seasonal Limits

The Protocol includes assessment of nutrients and diel DO ranges against benchmark values, including in the non-growing season. During the non-growing season, nutrients do not stimulate substantial algal growth due to much lower temperatures and decreased solar radiation. It is also not apparent that any of the invertebrate metrics were evaluated during winter months when insect life is naturally dormant or greatly reduced. As such, nutrient concentrations in the non-growing season are irrelevant to plant growth, and therefore both diel DO range and macroinvertebrate conditions. Thus, the Protocol should not assess non-growing season benchmarks with respect to aquatic life use impairment.

9. Citations Rely on Outdated/Misapplied Opinions

The Protocol cites a number of scientific, peer-reviewed studies as the basis for the proposed assessment Protocol. In particular, the Protocol cites Miltner and Rankin (1998), Dodds and Welch (2000), Slavik et al. (2004), Miltner (2010), and Yuan (2010) as the basis for the linkage between increased productivity and photosynthesis/respiration, photosynthesis/respiration and DO fluctuation/low DO levels, and DO flux/low DO and biological community structure. On the whole, these studies have been misapplied in the context of this Protocol and, in any event, the studies are outdated and should not be used as the basis for Pennsylvania's nutrient assessment strategy.

All of the referenced studies were prepared prior to the release of EPA's guidance on the use of stressor-response evaluations for nutrient criteria application. As a consequence, none of these studies properly account for confounding factors. For example, Miltner (2010) used linear regressions as the basis for the conclusions presented in this report. This type of regression was the focus of the SAB review and determined to be inappropriate without explicit consideration of confounding factors. Moreover, the author of this paper was a participant in the OEPA TAG that eventually recommended procedures that departed from the Protocol-type approach.

The Slavik *et al.* (2004) study assessed nutrient impacts in the Kuparuk River in northern Alaska which discharges to the Arctic Ocean. This enrichment study focused on an oligotrophic stream unlike any streams in Pennsylvania. Even after enrichment, the stream phosphorus concentration was less than the phosphorus concentration observed in most Pennsylvania streams. As a result of the fertilization experiment, the stream became dominated by moss. We are not aware of any Pennsylvania streams that exhibit similar shifts in the aquatic plant community. Before this study can be used to support any nutrient assessment protocol in Pennsylvania, its relevance must be justified.

Finally, the study by Yuan (2010) focused on the effects of excess nutrients on stream invertebrates from observational data. While this would appear to have some relevance to the concern in Pennsylvania (nutrients affecting macroinvertebrate community), the actual study was based entirely on data from streams in the western United States. The study appears to be an evaluation of the use of propensity scores as a technique to estimate the effects on increased nutrients on streams. This is the same type of study criticized by the SAB and cannot be used to support these assessment procedures. Moreover, the study found that in smaller, closed-canopied streams, increases in nutrients were associated with small increases in total richness that were not statistically significant. This finding does not support the proposed nutrient assessment Protocol.

Summary

The proposed nutrient impact assessment Protocol represents a new attempt to interpret the State's narrative water quality standard with regard to aquatic life impairment by nutrients. This very complex problem has been reduced to a 27 page Background Report that is deficient for the reasons summarized below and discussed in greater detail in the comments below.

Summary of Major Deficiencies

1. Endpoints (macroinvertebrate metrics, DO flux) are not directly affected by nutrients.
2. Methodology that was applied (linear regression) has already been rejected by SAB. Stressor-Response evaluations do not address confounding factors.
3. No analysis of excessive algal growth or impairments associated with algal growth.
4. Threshold concentrations for TP/TN set at levels that do not limit plant growth.
5. Ignores studies (including many DEP studies) showing nutrient regulation in streams will not reduce plant growth.
6. Analyses presume that invertebrates are sensitive to DO flux without any demonstration that DO flux, and not low DO, impairs invertebrates.
7. Approach presumes that TN adversely affects invertebrates.
8. Assumes nutrients exert adverse effect during the winter contrary to conceptual model.
9. Ignores upstream/ecoregional conditions which may influence macroinvertebrates and plant growth.
10. Inappropriate data averaging and metrics: maximum nutrient concentration/maximum DO swing does not drive assessment. All other evaluations based on average concentrations.
11. Failed to account for physical/chemical characteristics that affect DO variability and invertebrate metrics.

Given these significant deficiencies, the draft Nutrient Impact Assessment Protocol must be withdrawn and significantly revised using an expanded database and a scientifically defensible methodology. Given the complexity of this analysis and its potentially large economic impact, any revised proposal should be subject to review by an independent scientific panel before it is released for public comment.